Improvement And Evaluation Of Loss Production Opportunity Because Of Scale At Arh Field Using Analytical Hierarchy Process (Ahp)

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ABSTRACT

Indonesia, once a prominent oil-producing country and a member of the Organisation of the Petroleum Exporting Countries (OPEC), has experienced a decline in oil production over the past decade, despite a rising domestic demand for oil. The primary purpose of a corporation is to generate profit from its business operations. For an oil and gas corporation, profit is derived from the extracted oil. To attain oil production and profitability, a corporation will establish a key performance indicator (KPI) to assess its capacity to meet specified objectives. Crystal deposits from scale create impediments and elevate pressure loss, resulting in diminished oil output. The Scale problem significantly contributes to production losses, impacting output achievements from 2022 to 2024, resulting in a total loss of 98,946 barrels of oil. The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making methodology used in this research to obtain the best alternative to diminished the problem. By using the AHP method, company can obtain the big revenue and avoid losses based on the priority and criteria.

INTRODUCTION

Indonesia, once a prominent oil-producing country and a member of the Organisation of the Petroleum Exporting Countries (OPEC), has experienced a decline in oil production over the past decade, despite a rising domestic demand for oil. The Government has undertaken various initiatives through the Special Task Force for Upstream Oil and Gas Business Activities of the Republic of Indonesia (SKK Migas) to enhance oil production and satisfy domestic requirements.

SKK Migas has declared a vision of achieving the objective of oil production of 1-million-barrel oil per-day and 12 billion standard cubic feet gas per-day in 2030 at the International Convention on Indonesian Upstream Oil and Gas (IOG) 2020, which was held in Jakarta. This measure reflects the Government's dedication to fulfilling domestic energy requirements.

The primary KPI of the business process at PT Perkasa ARH Field is the attainment of oil production targets. The graph indicates that during the previous two years, production from ARH Field has consistently fallen short of the established targets of 85% for 2023 and 95% for 2024, as shown in Figure 1. Production failure issues are typically found through Low and Off analysis. The Low and Off method is employed internally by PT. Perkasa to discover issues that lead to production losses. If the wells are experiencing low output, it indicates a decline in production; conversely, if the wells are inactive, they cease oil production, resulting in a loss of output.

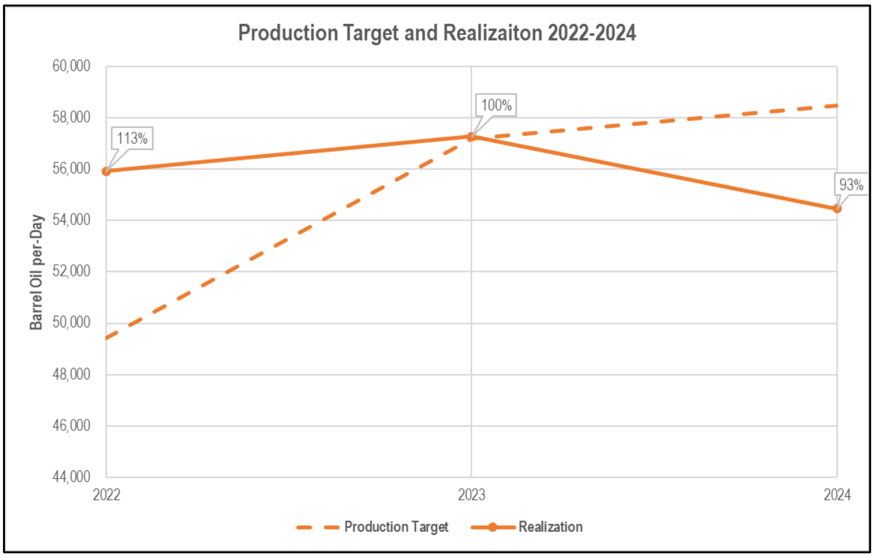


Figure 1. Production Achievement of ARH Field in the last 3 Years

The larger the Low and Off settings, the more significant the production loss, and conversely. The Scale problem significantly contributes to production losses, impacting output achievements from 2022 to 2024, resulting in a total loss of 98,946 barrels of oil. The issues must be assessed and rectified promptly, identify the fundamental cause, and enhance the Scale Prevention Method. To augment oil output and revenue while mitigating further losses for the Company.

The enhancements will be implemented during the Improve Phase. Multiple potential options will be delineated in this phase. The optimal answer will be identified using the Analytic Hierarchy Process (AHP), a frequently employed method for decision-making in complex scenarios, shown in Figure 2.

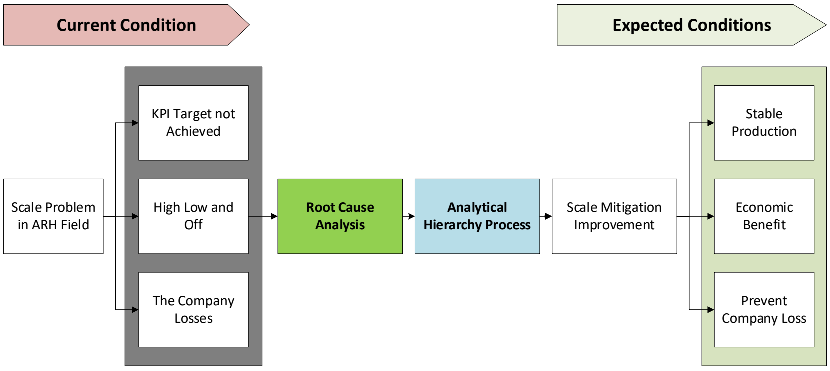


Figure 2

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making methodology developed by Thomas Saaty in the late 1970s. AHP serves as a tool to assist in making decisions related to complex problems (Rovaldi, 2022). It is capable of evaluating both intangible and measurable criteria. Numerous prominent researchers have applied this method across various fields, including conflict resolution, criteria weighting, and decision-making (Irvanizam et al., 2021). Apply the priorities derived from the comparisons to weight the priorities of the elements in the next level. Repeat this process for every element. Then, for each element in the lower level, sum its weight values to determine its overall or global priority. Continue this process of weighting and summing until the final priorities of the alternatives at the lowest level are determined.

RESEARCH METHOD

To make a structured decision and establish priorities, it is necessary to break down the decision-making process into the following steps (Saaty, 2008):

1. Identify the problem and determine the type of information required.
2. Organize the decision hierarchy starting from the goal at the top, followed by broad objectives, and then the intermediate levels.
3. Create a series of pairwise comparison matrices. Each element in a higher level is used to compare the elements in the level directly below it, in relation to that higher element.

Data Collection Method

The data to be used in this research are based on the internal company's data and the results of Focus Group Discussion (FGD). The internal company's data used are showed in Table 1 below.

Table 1. Data Collection Method

Type of Data	Source of Data
Daily Production Report	Daily Production e-mail (Internal Company Access)
Kerja Ulang dan Perawatan Sumur (KUPS) Report	Monthly Report by e-mail (Internal Company Access)
Subsurface Data	Subsurface Development Team Share folder (Internal Company Access)
Scale Composition	ARH Field Laboratory Test (Internal Company Access)

The results from the FGD serve as primary data, while internal company data acts as secondary data to support the discussions and analysis during the FGD. The internal company data will be utilized in the Define and Measure Phases to assess and evaluate the current business processes. The FGD will take place during the Analyse and Improve Phases, particularly when developing cause-and-effect analyses, risk assessments, and AHP to identify the optimal solution. The FGD will involve all stakeholders engaged in the stimulation and well services operation.

Data Analysis Method

This research will be carried out using a qualitative approach, where internal company data and FGD discussion results will be analyzed to address the research questions. The internal company data will be utilized to identify and assess the existing business processes, as well as evaluate their performance.

The qualitative method will be used to identify the root causes of issues and suggest improvement solutions, which will be discussed through the FGD. Additionally, this method will help analyze the available data, including both internal company data and other relevant information, to achieve the research objectives.

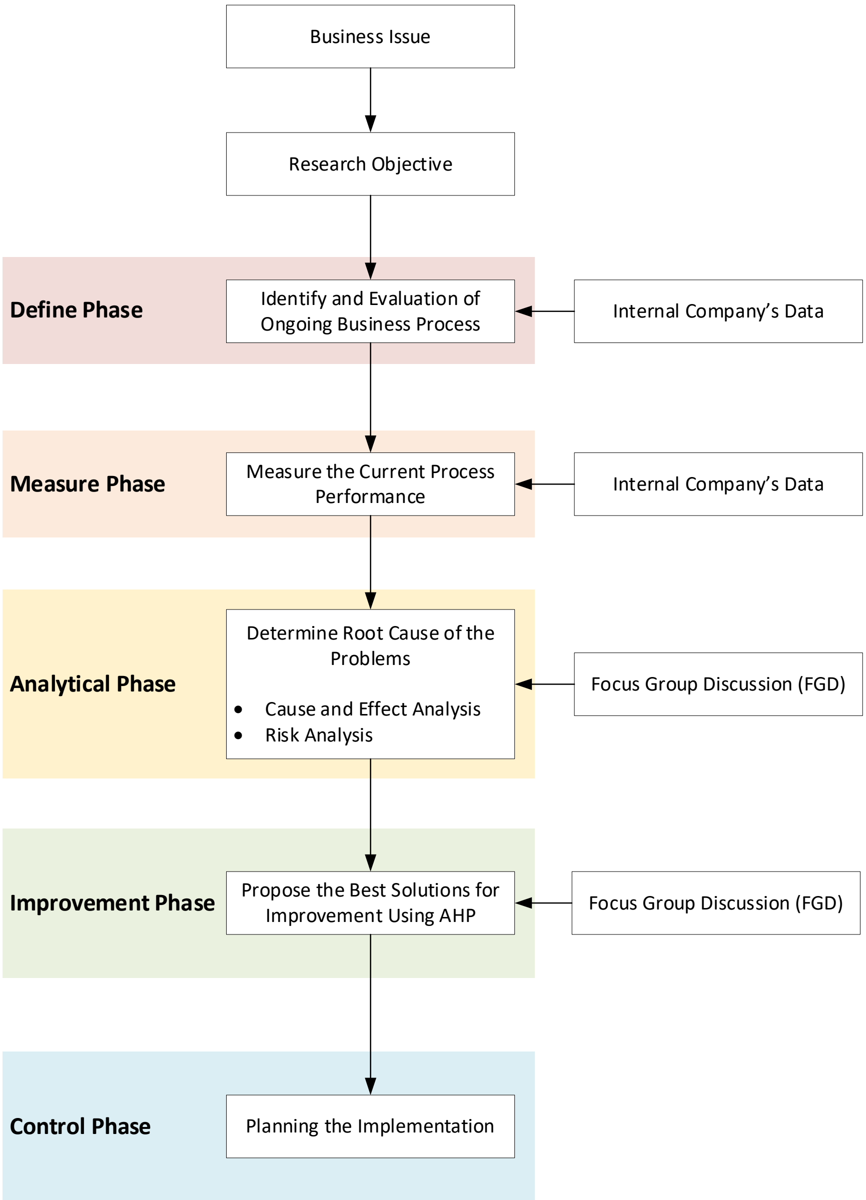


Figure 3 Research Design

RESULTS AND DISCUSSION

Define Phase

The first phase of this studi is Define Phase. In this phase, author will describe the business processes of Production Operation that is going to capture the condition where such a good process could not be completed. The not completed process will give some opportunities for improvement that can be determined.

When a decline in oil well production, the Subsurface Development (SSD) team will assess the subsurface data from the well, including residual oil, reserves, and water cut. The Petroleum Engineering (PE) team will do further study of the existing well history to reinforce the fundamental cause associated with scale accumulation in the production tubing series. The PE team will calculate the required chemical design for injection and determine the injection position. The design is then presented to the Well Service (WS) team to develop a well service program. Upon the creation of the well servicing program, the Well servicing team will mobilize the oil rig and the necessary equipment to install the chemical injection mandrel. Upon installation of the Chemical Injection Mandrel, the Production Operation (PO) team will commence the injection of scale inhibitors and will monitor well output and chemical use on a daily basis.

Throughout monitoring, the WS team and PO team will perform regular inspections using a Gauge Cutter to confirm the absence of scale accumulation in the production tubing that might obstruct oil production. If scale remains in the production tube designated with the GC tag, the SSD team and PE team will assess the issue. A new chemical injection design will be derived from the evaluation data and presented to the WS team and PO team. An increased frequency of scale in the well correlates with a greater drop in output.

The oil production goal, a key performance indicator (KPI) for the ARH Field, has not been met in the last three years, as outlined in the business problem. In the ARH Field, only a small number of wells encounter scale growth issues. Still, these wells exhibit significant production, resulting in significant production loss. According to the low and off statistics from 2024, there was a production loss of 31,000 BOE. When a well has a decreased production, evaluation of its scale growth will be conducted with a Gauge Cutter. If the gauge cutter results suggest scaling, frequent tubing clearances must be performed. Between 2022 and 2024, a total of 25 tubing clearance programs were executed utilizing the Coiled Tubing Unit, along with 25 Low Acid Bullhead programs, and 6 Scale Inhibitor Injection Program. The stability of well production further illustrates this point. As the number of stimulation programs increases, the stability of well production decreases, resulting in a heightened potential for production loss. This issue requires immediate evaluation and improvement. It is essential to identify the root cause and implement improvements to prevent the accumulation of scale on the production tubing series. The objective is to enhance oil production and profitability for the company while mitigating further losses.

Measure Phase

The purpose of stimulation is to increase oil production while mitigating the reduction in diameter resulting from scaling up. Extended periods of production stability in the well will lead to the achievement of targeted oil production levels. On the other hand, frequent stimulation of the well can prevent the achievement of production targets, potentially leading to revenue losses for the company.

Analyze Phase

The cause-and-effect analysis was conducted through focus group discussions (FGDs), which included all stakeholders involved in the Scale Prevention process. Participating stakeholders have been identified during the Define Phase. The objective of conducting FGD is to solicit opinions and input from all stakeholders in order to identify the underlying factors contributing to low production on a scale. The parties that participated in the ideation and discussion during the FGD are listed in Table 2. The opinions of all parties were expressed in accordance with their respective responsibilities. The fishbone diagram was selected as the instrument to analyse the potential cause and effect that occurred, and the discussion results are delineated in it.

Table 2. The Parties Involved in FGD

Respondent	Responsibilities	Role	Relation to the Objectives
Manager Subsurface Development	As the leader of the SSD Team, which has a unique level of expertise in the subsurface area	Provide subsurface data and oil reserves for wells that having low production.	To get a subsurface evaluation related to the Low Production problems caused by Scale growth
ARH Field Manager (Author)	As the leader of the ARH Field, which has responsible for all the production operation in ARH Field and as a leader of FGD.	Provide the authority of all operation changes in ARH Field.	To authorize the submission of data, the implementation of changes, and the establishment of a schedule for their execution.
Asst. Manager Petroleum Engineering (Facilitator)	As the leading member of the PE Team, which is responsible for the well operation in the ARH Field and as the facilitator of FGD	Provide oil forecasting potential and chemical injection design	To analyse current situation and identify root cause.
Petroleum Engineer	As the PE Team, which is responsible for the well operation in the ARH Field.	Provide oil forecasting potential and chemical injection design	To analyse current situation and identify root cause.
Asst. Manager Well Service	In the capacity of the WS Team. The responsibility for the Well Service position is to install the additional equipment or stimulation program.	Create the Well Service Program and supervise the Well Service activity	To provide operational data in identifying the root cause related.
Engineer Well Service	As the WS Team. The responsibility for the Well Service position is to install the additional equipment or stimulation program.	Create the Well Service Program and supervise the Well Service activity	To provide operational data in identifying the root cause related.
Asst. Manager Production Operation	As the leader of PO Team. The responsibility for managing surface facilities and chemical.	To ensure chemical injection doses and routine check of surface scale coupon.	To identify the problems often occurred.
Senior Supervisor Production Operation	The responsibility for monitoring production on daily basis and troubleshoots the problems.	To ensure chemical injection doses and routine check of surface scale coupon.	To identify the problems often occurred.

Figure 4 depicts the fishbone diagram resulted from discussion through FGD. The causes of the low production problem were analysed from 5 aspects, namely machine, material, environment, man, and method. The discussions and analysis were conducted by assessing the well performance, as described in the Define Phase, and the results of field observations by each party involved. Additionally, professional judgment was considered based on the expertise perspectives of the parties as subject matter experts (SME).

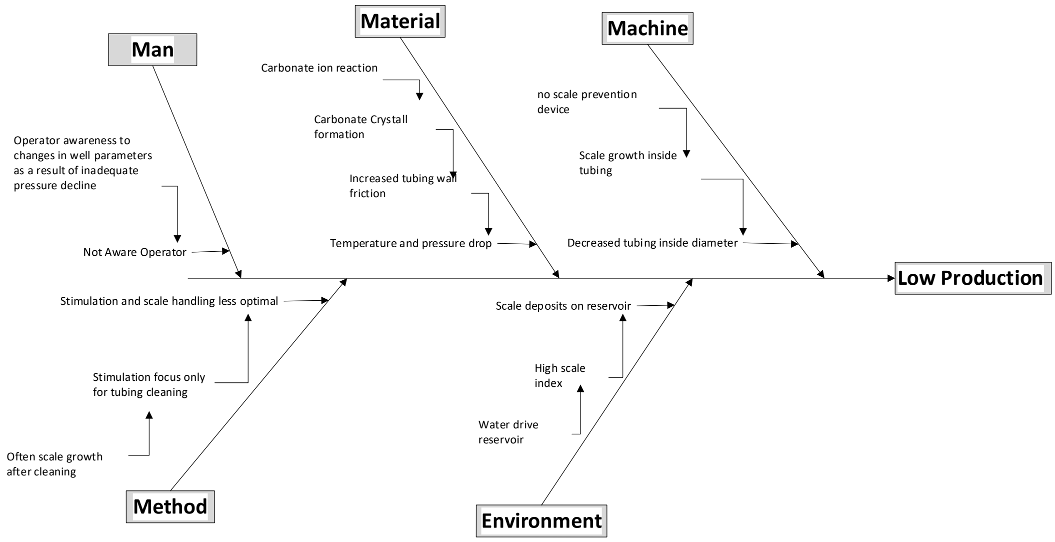


Figure 4. Fish-bone diagram

Analyze Phase

In the Analyze Phase before, the root causes of the problem were analyzed, which identified a well failure due to scale problem. Unavailability of scale growth prevention in wellbore is the main root cause which results in low production of natural oil well. At the Improve Phase, it will discuss various alternative solutions to overcome scale problem at natural flow wells. Then, the best alternative solution will be determined using the Analytic Hierarchy Process (AHP).

Several possible alternative solutions were identified to solved the scale build up problem. The consideration for selecting these alternatives includes contract availability, cost, safety, delivery time, and production stability. The solution must either avoid the scale developed at the tubing string, the well head or the flowline. The alternatives proposed are:

1. Scale inhibitor injection direct to tubing string using mandrel

2. Squeeze scale inhibitor (stimulation job)
3. Scale prevention using electric current (FAST Scale)
4. Scale clean out using coiled tubing unit.

The optimal alternative identified by the Analytic Hierarchy Process (AHP) methodology. The analysis will identify the optimal strategy for addressing the low production due to scale issue. The procedures in AHP are:

1. Set up decision hierarchy
2. Construct pairwise comparison
3. Synthesize the result to determine the best alternative

Set Up Decision Hierarchy

Selection of the alternative based on criteria derived from the focus group discussion (FGD). A comprehensive discussion is conducted with Subject Matter Experts (SMEs) which will then also be used to form pairwise comparisons. With the FGD, the criteria that must be owned by each alternative solution will be obtained. The criteria include cost, equipment availability, delivery time, production sustainability time, and safety. Upon defining the problem, criteria, and possible solutions, the decision hierarchy tree can be formed as seen in Figure 5.

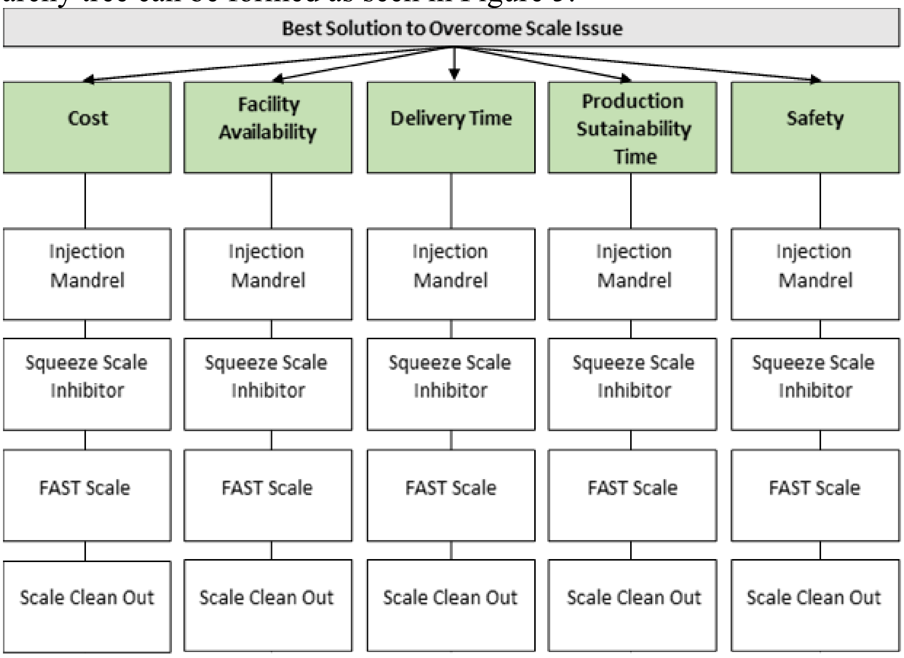


Figure 5. Best Solution to Overcome Scale Issue

Construct Pairwise Comparison

A pairwise comparison matrix defines the relative significance of two criteria, sub-criteria, and different solutions (Rovaldi, 2022). To facilitate comparisons, a numerical scale is required to denote the extent to which one element surpasses or dominates another for the specified criterion or attribute (Saaty, 2008). In order to develop the pairwise comparisons, the author performed a survey of the parties involved in the Production Operation and Management activities, who were defined as Subject Matter Experts (SMEs). The assessment was completed by assigning subjective weights based on each SME's knowledge and experience. The SMEs come from all departments and have diverse work experiences. The results of a pairwise comparison matrix for one of the SME shown from Table 3 to Table 8.

Table 3. Pairwise Comparison Matrix on Criteria

Criteria	Cost	Equipment Availability	Delivery Time	Production Sustainability Time	Safety
Cost	1.00	4.00	5.00	3.00	0.25
Equipment Availability	0.25	1.00	1.00	1.00	0.17
Delivery Time	0.20	1.00	1.00	2.00	0.25
Production Sustainability Time	0.33	1.00	0.50	1.00	0.33
Safety	4.00	6.00	4.00	3.00	1.00

Table 4. Pairwise Comparison Matrix of Alternatives Solution for Cost Criteria

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	
SI Injection Mandrell	1.00	3.00	4.00	4.00	
Squeeze Scale Inhibitor Injection	0.33	1.00	2.00	5.00	
FAST Scale	0.25	0.50	1.00	4.00	
Scale Clean Out	0.25	0.20	0.25	1.00	

Table 5. Pairwise Comparison Matrix of Alternatives Solution for Equipment Availability Criteria

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	
SI Injection Mandrell	1.00	7.00	5.00	2.00	
Squeeze Scale Inhibitor Injection	0.14	1.00	3.00	0.50	
FAST Scale	0.20	0.33	1.00	0.20	
Scale Clean Out	0.50	2.00	5.00	1.00	

Table 6. Pairwise Comparison Matrix of Alternatives Solution for Delivery Time Criteria

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	
SI Injection Mandrell	1.00	5.00	4.00	1.00	
Squeeze Scale Inhibitor Injection	0.20	1.00	3.00	0.14	
FAST Scale	0.25	0.33	1.00	0.17	
Scale Clean Out	1.00	7.00	6.00	1.00	

Table 7. Pairwise Comparison Matrix of Alternatives Solution for Production Sustainability Time Criteria

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	
SI Injection Mandrell	1.00	3.00	3.00	4.00	
Squeeze Scale Inhibitor Injection	0.33	1.00	0.13	0.13	
FAST Scale	0.33	8.00	1.00	6.00	
Scale Clean Out	0.25	0.17	0.17	1.00	

Table 8. Pairwise Comparison Matrix of Alternatives Solution for Safety Criteria

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	
SI Injection Mandrell	1.00	5.00	3.00	3.00	
Squeeze Scale Inhibitor Injection	0.20	1.00	0.20	0.20	
FAST Scale	0.33	5.00	1.00	1.00	
Scale Clean Out	0.33	5.00	1.00	1.00	

Synthesize the Result to Determine the Best Alternative

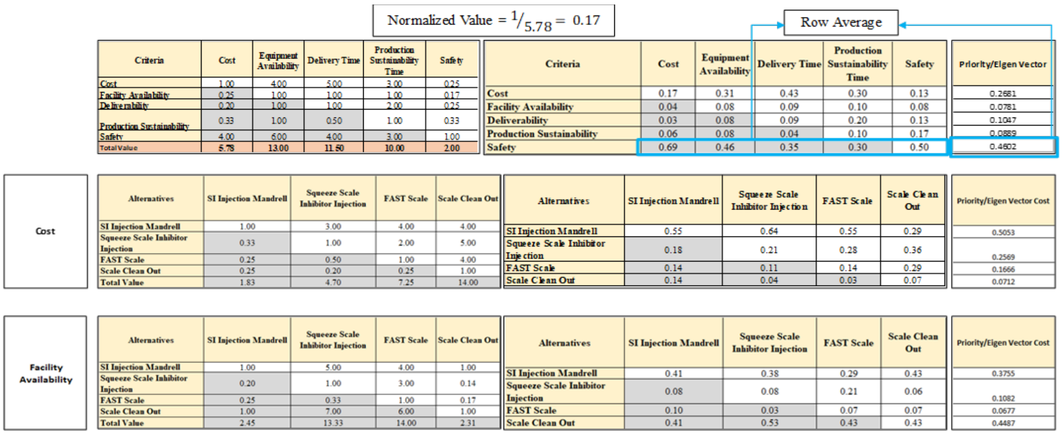
Synthesizing results involves determining relative weight, calculating consistency ratio, and prioritizing alternative solutions. This phase makes use of the previously used pairwise comparison matrix from Asst. Manager Petroleum Engineering. The step is divided by 3 steps: determine the relative weight, calculate the consistency ratio (CR), and prioritize the alternative solutions.

Determine the Relative Weight

To get the relative weight, first normalize the pairwise comparison matrix and calculate the average of each row to obtain the relative priority of each criterion. The steps involve as follow and shown in Figure 6.

1. Step 1 calculates the normalized value by dividing each value in the column J matrix by the total value of column J.
2. Step 2: Determine the eigen vector by finding the average row value in the normalized matrix.

Figure 2 shows the results of the cost and equipment availability criteria and sub-criteria. The same processes were used for additional sub-criteria, such as delivery time, manufacturing sustainability time, and safety.



Criteria	Cost	Equipment Availability	Delivery Time	Production Sustainability Time	Safety
Cost	1.00	4.00	5.00	3.00	0.25
Facility Availability	0.25	1.00	1.00	1.00	0.17
Deliverability	0.20	1.00	1.00	2.00	0.25
Production Sustainability	0.33	1.00	0.50	1.00	0.33
Safety	4.00	6.00	4.00	3.00	1.00
Total Value	5.78	13.00	11.50	10.00	2.00

Criteria	Cost	Equipment Availability	Delivery Time	Production Sustainability Time	Safety	Priority/Eigen Vector
Cost	0.17	0.31	0.43	0.30	0.13	0.2681
Facility Availability	0.04	0.08	0.09	0.10	0.08	0.0781
Deliverability	0.03	0.08	0.09	0.20	0.13	0.1047
Production Sustainability	0.06	0.08	0.04	0.10	0.17	0.0889
Safety	0.69	0.46	0.35	0.30	0.50	0.4602

Cost

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out
SI Injection Mandrell	1.00	3.00	4.00	4.00
Squeeze Scale Inhibitor Injection	0.33	1.00	2.00	5.00
FAST Scale	0.25	0.50	1.00	4.00
Scale Clean Out	0.25	0.20	0.25	1.00
Total Value	1.83	4.70	7.25	14.00

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	Priority/Eigen Vector Cost
SI Injection Mandrell	0.55	0.64	0.55	0.29	0.5053
Squeeze Scale Inhibitor Injection	0.18	0.21	0.28	0.36	0.2569
FAST Scale	0.14	0.11	0.14	0.29	0.1666
Scale Clean Out	0.14	0.04	0.03	0.07	0.0712

Facility Availability

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out
SI Injection Mandrell	1.00	5.00	4.00	1.00
Squeeze Scale Inhibitor Injection	0.20	1.00	3.00	0.14
FAST Scale	0.25	0.33	1.00	0.17
Scale Clean Out	1.00	7.00	6.00	1.00
Total Value	2.45	13.33	14.00	2.31

Alternatives	SI Injection Mandrell	Squeeze Scale Inhibitor Injection	FAST Scale	Scale Clean Out	Priority/Eigen Vector Cost
SI Injection Mandrell	0.41	0.38	0.29	0.43	0.3755
Squeeze Scale Inhibitor Injection	0.08	0.08	0.21	0.06	0.1082
FAST Scale	0.10	0.03	0.07	0.07	0.0677
Scale Clean Out	0.41	0.53	0.43	0.43	0.4487

Figure 6. Estimating Relative Weight

Calculate the Consistency Ratio

The steps to calculate the consistency ratio are as follows:

1. Step 1: Calculate the weighted sum by multiplying each value in the first column of the pairwise comparison matrix by the eigen vector of the first considered. The procedure is the same for the remaining things.
2. Step 2, weighted sum divided by eigen vector.
3. In Step 3, calculate Lambda Max as the average weighted total.
4. In Step 4, calculate the consistency index (CI) using the formula below,

$$(Lamda\ Max - n)/(n - 1)$$

Where,

n = Number of Criteria Applied

5. In step 5, calculate the consistency ratio (CR) using the formula below,

$$CR = CI/RI$$

Where,

RI = Random Index. Consistency index of random generated pairwise comparison matrix.

Table 9 shows the RI number. The RI number will depend on the number of items being compared. In this study, Author use 5 criteria and 4 sub-criteria, so the RI value for each criteria and sub-criteria is 1.12 and 0.9 in a row.

Table 9. Pairwise Comparison Matrix of Alternatives Solution for Safety Criteria

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

6. The next is Step 6, consistency check. The data used will be classified as consistent if the CR value <0.1 and it can be proceeded to the next procedure.

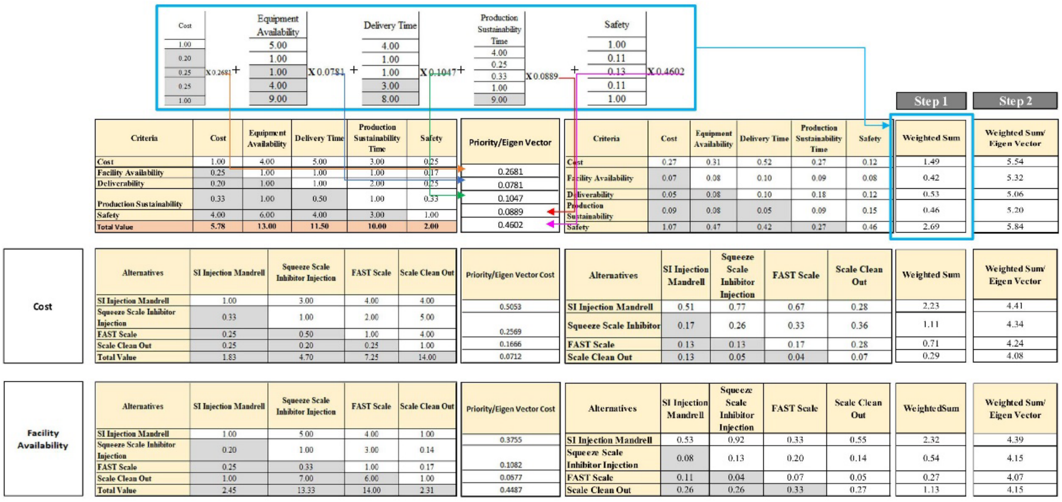


Figure 7. Consistency Ratio Calculation

	Step 3	Step 4	Step 5	Step 6
	Lambda Max	Consistency Index	Consistency Ratio	Consistent if CR < 0.1
Criteria	5.390	0.098	0.087	Consistent
Cost	4.266	0.089	0.099	Consistent
Facility Availability	4.188	0.063	0.070	Consistent
Deliverability	4.244	0.081	0.090	Consistent
Production Sustainability	4.069	0.023	0.026	Consistent
Safety	4.156	0.052	0.058	Consistent

Figure 8. Consistency Ratio Calculation (Cont'd)

Prioritize the Alternative Solutions

The final step involves determining the priority of the alternative solutions. This is achieved by multiplying the priority matrix corresponding to each criterion by the respective criterion's weight. The alternative with the highest resulting priority value is identified as the optimal solution.

Criteria	Cost	Equipment Availability	Delivery Time	Production Sustainability Time	Safety
SI Injection Mandrell	0.51	0.53	0.38	0.46	0.50
Squeeze Scale Inhibitor Injection	0.26	0.13	0.11	0.07	0.06
FAST Scale	0.17	0.07	0.07	0.40	0.22
Scale Clean Out	0.07	0.27	0.45	0.07	0.22

×

Criteria Weight
0.2681
0.0781
0.1047
0.0889
0.4602

=

Alternative Solution Priority
0.4871
0.1254
0.1934
0.1942

Figure 9. Estimating Relative Weight

From the Figure 4.11. above, can be seen that personal judgement priority of Asst. Manager Petroleum Engineering is scale inhibitor injection mandrel. Another SME could result different perspective and judgement.

AHP Final Results

After all the SMEs data are consistent, the final results could be obtained by averaging all SMEs. The calculation shown at Figure 10 below. By averaging all the SMEs, the priority can be concluded, shown in Table 10 by criterion and Table 11 by alternative solution.

Criteria	Cost	Facility Availability	Deliverability	Production Sustainability	Safety
SI Injection Mandrell	0.5384	0.4029	0.3251	0.3299	0.4053
Squeeze Scale Inhibitor Injection	0.2009	0.1451	0.1897	0.1389	0.0654
FAST Scale	0.1396	0.3258	0.0592	0.2119	0.1703
Scale Clean Out	0.1211	0.1262	0.4260	0.3192	0.3590

×

Criteria Weight
0.4122
0.0454
0.0733
0.1172
0.3519

=

Alternative Solution Priority
0.44536
0.14258
0.16144
0.25062

Figure 10. Estimating Relative Weight

Table 10. The Priority by Criteria

Criteria	Percentage
Cost	41.2%
Equipment Availability	4.5%
Delivery Time	7.3%
Production Sustainability Time	11.7%
Safety	35.2%

Table 11. The Priority by Alternative Solution

Criteria	Percentage
SI Injection Mandrell	44.5%
Squeeze Scale Inhibitor Injection	14.3%
FAST Scale	16.1%
Scale Clean Out	25.1%

From the results above, it can be seen that the priority by criteria is Cost with 41.2%. Then safety with 35.2%, production sustainability time with 11.7%, delivery time 7.3%, and equipment availability with 4.5%. Cost and safety are the main criteria to determine alternative solutions. Based on the Table 11, the best alternative solution to overcome low production due to scale issues in ARH Field is Scale Inhibitor injection mandrel with 44.5% priority.

Control Phase

Based on the analysis of previous sub-chapter Improve Phase, Scale clean out has been selected as the solution to improve the well performance and prevent scale build up in the ARH Field. The improvement will be implemented on the existing natural flow wells and the ESP wells. The detail of implementation and control plan shown in Table 12 and the timeline shown in Figure 11.

Table 12. Detail Implementation Plan

	HOW	WHEN	WHO	WHERE	OUTPUT
Data Acquisition	Data of depth of Scale build up from last well services job	Q2-2024	WI Team PE Team	Wells	Data of scale build up depth's
	Scale index, temperature, pressure, Production data	Q3-2024	PO Team PE Team Lab Team	Lab Wells	- Scale Index - Temperature - Pressure - Production data
Equipment Planning	Material request	Q4-2024	PE Team	Warehouse	Material readiness
	Material delivery	Q2-2025	PE Team		
Rig Allocation	Oil rig install the equipment	Q3-2025 Q4-2025	WS Team PE Team	Well	The equipment installed
Implementation Monitoring	Scale coupon on flowline	Q2-2025	PO Team	Well	Ensure scale build up inside flowline
	Running Gauge Cutter	Q3-2025	WS Team PE Team	Well	Ensure scale build up inside tubing string

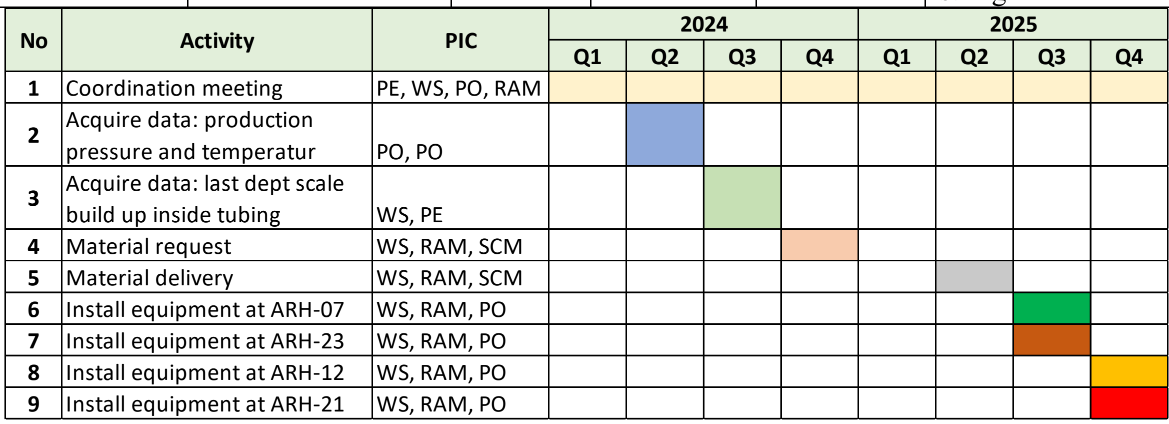


Figure 11. SI Injection Mandrel Implementation Timeline

CONCLUSION

Based on the analysis that has been done and findings in the previous chapters, as well as to answer the questions of this research, then the conclusion and suggestions proposed are presented in this chapter.

Conclusions

1. The main cause of the scale problems is the high salinity or scale index of water produced from the wellbore.
2. High scale index of the water produced causing the scale build up along the tubing string, well head, flowline and another surface facility. The ARH field is an oil field producing high water produced, the water is produced to the surface together with the oil. The presence of scale build up inside tubing string will result in non-optimal pump performance, which narrowing the production string.
3. The proposed solution in order to improve the business situations is using a chemical injection scale inhibitor direct to tubing string.
4. The scale inhibitor injection will prevent scale precipitate from water during pressure and temperature drop along tubing string.
5. The chemical scale inhibitor also become an effective insulation inside pipeline and prevent the ion connection between scale and the metal.

Recommendation

1. The implementation of chemical injection scale inhibitors on the surface flowline has been effectively proven. However, subsurface implementation requires further trial with consideration of high temperature and find the proper dosage of chemical used. Intense data collection is needed to see the impact of injection on scale growth inside tubing and flowline.

2. Coordination with service providers is essential to iterate the process of finding the right chemical and the right dosage. a lot of data and adjustments will be needed to get optimum results. This adjustment will be done in every well because each well has different characteristics in scale index, production rate and temperature so that it will produce different scale growth rates. this condition will require different chemical dosage of treatments.

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